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Jeffrey Ruby

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U.S. Army Topographic Engineering Center
ATTN: CETEC-PAO
7701 Telegraph Road
Alexandria, VA 22315-3864

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ANALYSIS OF TINS FOR DREDGED VOLUME COMPUTATION

Jeffrey G. Ruby
U.S. Army Topographic Engineering Center
ATTN: CETEC-TD-GS
7701 Telegraph Road
Alexandria, VA 22315-3864

BIOGRAPHICAL SKETCH

Mr. Ruby is a Mechanical Engineer with the U.S. Army Topographic Engineering Center. He received his Bachelor of Science degree in Mechanical Engineering from Virginia Polytechnic Institute and State University in 1992. He is currently involved in a number of software related projects which support the Corps of Engineers survey missions.

ABSTRACT

This paper will examine some of the commercially available software packages which can be used to create Triangulated Irregular Networks(TIN's) and compute dredge volumes from these TIN's. It will also give some guidance on selecting a package to use for calculating volumes from TIN's.

BACKGROUND

Triangulated Irregular Networks or TIN's are a relatively new method which can be used to calculate dredge volumes. In the TIN method, two modeled surfaces are compared to each other to determine a volume. This volume is calculated by summing the volumes of a finite number of individual prismoidal elements which are created from the two surface models.

TIN's offer several advantages over the average-end-area method, which is traditionally used to calculate dredge volumes. TIN's offer greater flexibility in the collection of survey data, since the data need not be aligned along pre-determined cross-section or profile lines. Dredge volumes from irregular sections, such as corners or turning basins, can be calculated easier from TIN's than from the average-end-area method.

One area that is particularly well suited to the TIN method is in the processing of multi-beam survey data. This data is usually collected in a sweep fashion where the survey vessel covers the entire survey area with data. A TIN surface can be created from this data which reflects the entire channel floor and not just the conditions at incremental sections along the bottom. Multi-beam data usually does not have cross-section or longitudinal lines which are used to calculate volumes in the average-end-area method.

While TIN's offer flexibility in data collection and can produce very accurate volumes, there are some drawbacks with the method.

Of particular interest to Corps of Engineers Districts is the documentation of the results. Because the technique is so computationally intensive, verification of results by manual methods is not feasible, or even impossible. Also, there are no commercially available software packages that are specifically designed to meet the needs of dredging applications, such as the computation of volumes on a station-by-station basis. Most of the packages that calculate TIN volumes are roadway and/or site design packages in which the user must tailor the input to get correct results.

With the above facts in mind, this paper will examine some of the software packages that are available in industry today which will perform TIN surface-to-surface comparisons. It will also attempt to give some guidance on the selection of a TIN package which may be used to calculate dredge volumes. In many of these packages, the TIN features are only a small part of a larger survey, roadway, or site design package which have many other functions and capabilities. This paper will only focus on the TIN/volume aspects of the packages. This is not, by any means, a complete list of TIN packages. There may be many more packages available which are just as suitable, if not more suitable, than some of the ones listed.

WHAT TO LOOK FOR IN A TIN PACKAGE

Minimum Requirements

When selecting a TIN package the user should be sure that, at a minimum, the package has the following features.

- The package has some facility to create a TIN surface from one of two sources; from a CADD file or from an ASCII file.

- The package has some facility to incorporate breaklines into a TIN surface. Breaklines will prevent the triangulation scheme from creating triangles across a given line. It is important to have this feature so that the design channel is triangulated correctly.

- The package has some facility to compare two different surface models.

Additional Features

Above are the minimum requirements of a TIN package. Below is a list of feature which can make a package easier to use. The more features the package has the more appealing the package will be.

- The package should allow the user to have some control over the creation of the TIN. Some common item such as maximum triangle length or clipping boundary should be available. Setting a maximum triangle length will prevent the software from creating large triangles over areas where there may be no data. A clip polygon will eliminate points that may be outside the area of interest.

• The package should be able to create a TIN surface from both ASCII files and CADD files. This gives the software more versatility and, in some cases, more speed.

• The product should be able to read a number of different file formats when building a TIN surface from an ASCII file. This will allow the user to import data from several different sources, without having to run the data through a conversion program. Some products will even allow free form file formats where the user can specify how the data are configured.

• The package should have a number of different selection mechanisms when building a TIN surface from elements in a CADD file. Some good features to look for are selection by fence, level, element type or single element. The more selection modes the package has, the easier it will be to use.

• The package should have a surface summary feature which gives information such as minimum and maximum X-Y-Z, point count, and triangle count. This can help the user verify the validity of the surface data.

• Packages that do most of the "overhead" are somewhat easier to use. These products maintain the intermediate file names themselves and require the user to enter only a surface name or description.

TEST DATA SETS

The software packages analyzed were tested for accuracy, run-time, and ease of use. Three data sets were used that represent 1) simulated survey data, 2) multi-beam data, and 3) dense single transducer data.

Simulated Data Set

The simulated data was a pseudo-random set of 11,000 points covering an area of approximately 25,000 square feet. There was one point in every five square foot section of the simulated area, but the location of the point within this five square foot area was generated randomly. The depth of the point was a randomly generated number between 9.00 and 10.99 feet, so the average depths of the points would be approximately 10 feet. The channel used in this area had toe lines 50 feet apart and 1000 feet long. It had side slopes of three-to-one. The channel had a design depth of 25 feet.

The randomly generated points would approximate a plane with a depth of 10 feet through this area which gives an approximate volume of cut of 52,778 cubic yards. Figure 1 shows the volume calculation. This is not the exact volume, because the points are not all 10 feet deep. It is, however, a good approximation which gives a good basis for a benchmark set. Figure 2 shows the design channel and the boundary of the survey data.

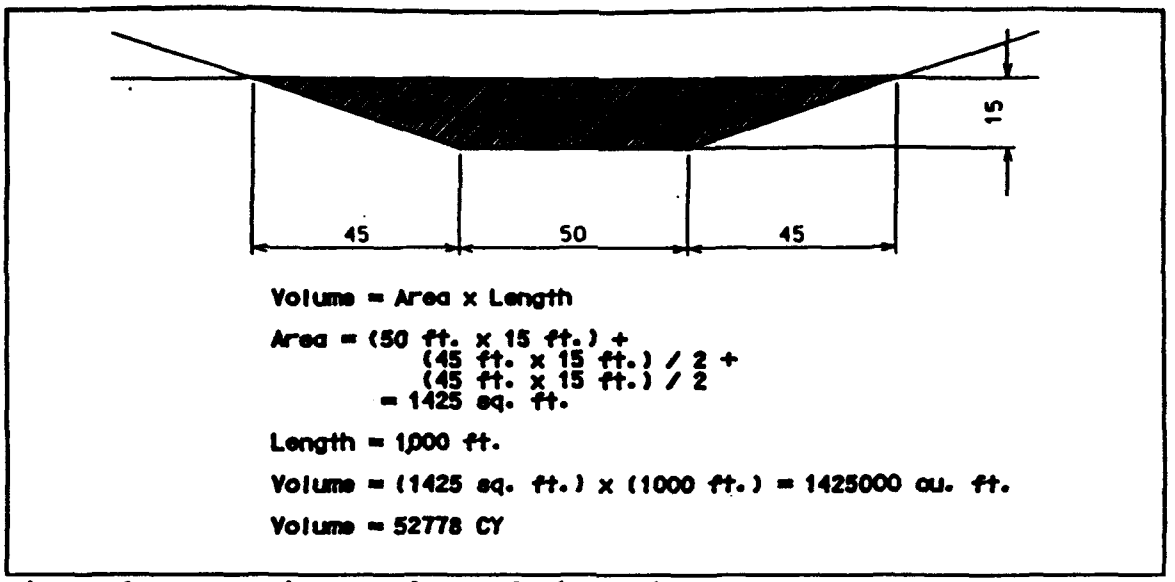

Figure 1. Approximate Volume of Simulation Set.

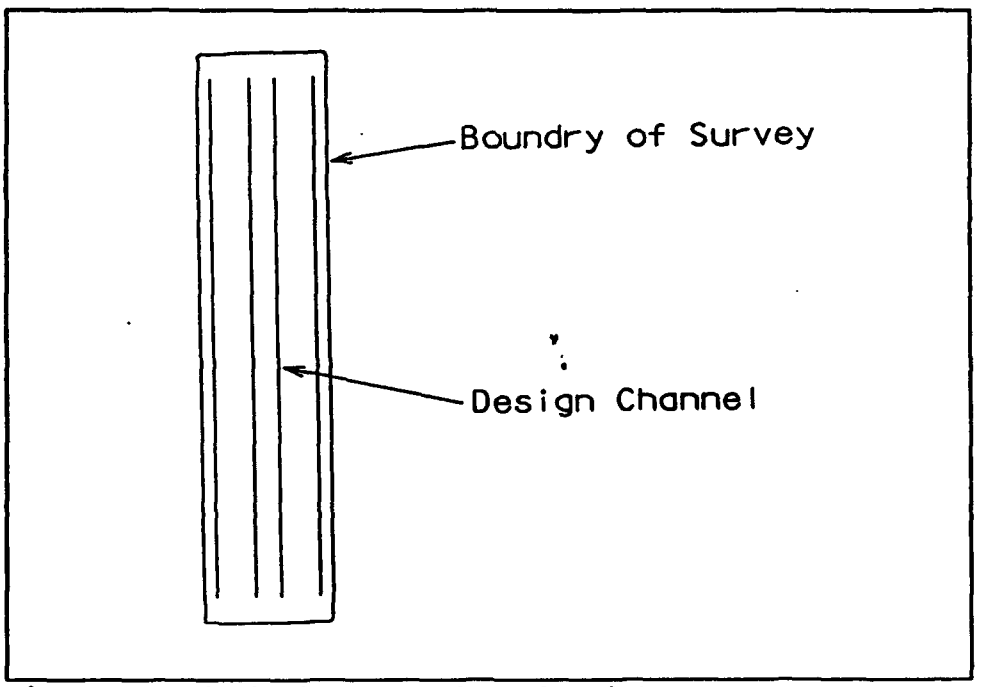

Figure 2. Simulation Data Channel and Survey.

Multi-Beam Data Set

This data set is an actual multi-beam data set taken from St. John Harbor in New Brunswick, Canada, by C & C Technologies of Lafayette, Louisiana. The survey covers an area approximately 800 meters by 230 meters and contains approximately 123,000 points. The channel was a ficticous channel made to fit into the data set. It is 35 meters deep and 50 meters wide with three-to-one side slopes. Figure 3 shows the design channel and the boundary of the survey data.

Single Transducer Data Set

The single transducer data set is an actual survey of a creek, Bonum Creek, in East-Central Virginia. This dense single transducer survey consisting of 8125 points was conducted by the Baltimore District. The design channel used is the actual channel for Bonum Creek. Figure 4 shows the design channel and the boundary of the survey data.

THE PACKAGES

Below is a list of packages that were analyzed for TIN volume computations. Volume results from each package using the test data sets agreed to within two percent of each other. Qualitative observations from the author are given.

Eagle Point Advantage Series

Eagle Point Advantage Series has a number of different modules for surveying/mapping/site design. The modules used for the DTM's were Surface Modeling and Site Design. For this test, MicroStation PC version was used.

Vendor: Eagle Point
Address: 4131 Westmark Drive
Dubuque, Iowa 52002
Phone: (800) 678-6565
Platforms: DOS, Sun(Unix)
Other Software Required: Can run as stand alone, or through MicroStation or AutoCAD.
As Tested: DOS Version on PC(486-33MHz, 8 MB RAM) with MicroStation PC Version 4.0

Likes:

- Good user interface. The tool palettes and dialog boxes function the same as those in MicroStation. For those familiar with the MicroStation CADD package, the interface is simple to understand and use.
- Good selection/masking feature for building the TIN surface from design file elements. Has a good "Project Manager" feature. The user creates a project and adds surfaces to this project. The user only needs to enter a surface description when working with multiple surfaces.
- Has the ability to set maximum triangle length.
- Imports lines as breaklines.

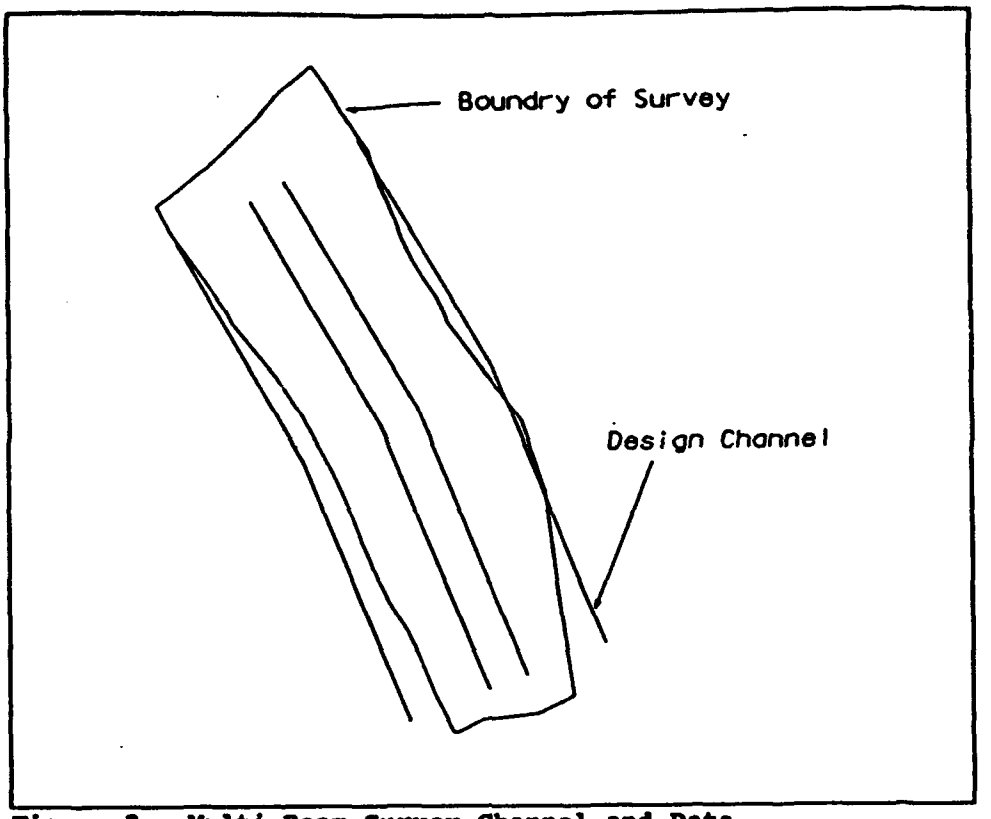

Figure 3. Multi-Beam Survey Channel and Data.

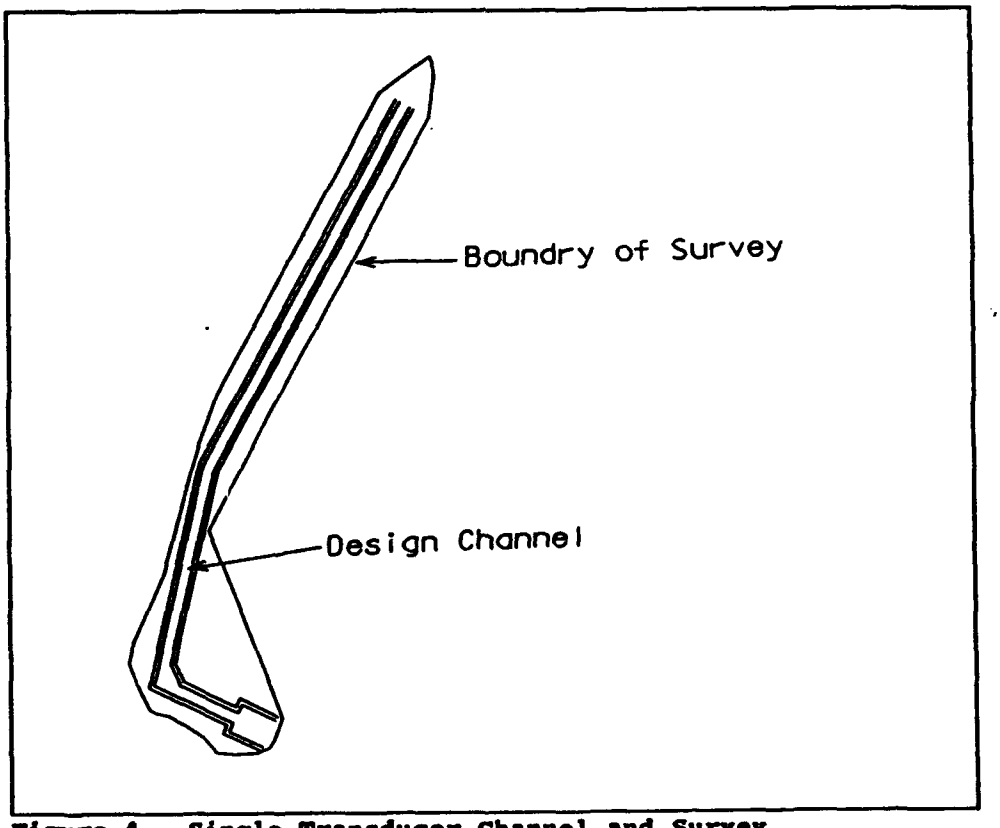

Figure 4. Single Transducer Channel and Survey.

Dislikes:
• Builds surfaces only from design file elements. Cannot build surfaces directly from ASCII files.
• User must select elements with a fence. In order to select from different levels, the user must mask them on/off or must manually turn on/off these levels which adds extra step to the process.
• Imports ASCII data into design file, but only in one format. To get ASCII data in different formats into a design file, a third module, Data Import, is required. CVTPC, which can be obtained free of charge from TEC, may also be used.
• The version tested has no surface summary feature.
• Writes volume results as text design file, which is inconvenient. Other elements may be overwritten, or a zoom command may need to be used to read the results if the text size is not correct.

GWN-DTM

GWN Systems Inc. has several different products for civil/site design. GWN-DTM, the Digital Terrain Modeling package for MicroStation PC, was used in this test.

Vendor: GWN Systems Inc.
Address: #200
11133 - 124 Street
Edmonton, AB T5M OJ2
Canada
Phone: (403) 452-0090
FAX: (403) 453-5207
Platforms: Unix(Clix), DOS, Sun
Other Software Required: MicroStation
As Tested: DOS Version on PC(486-33MHz, 8 MB RAM) with MicroStation PC Version 4.0

Likes:
• Building surfaces and volumes from design file elements is easy and straight-forward when the points and lines for the design channel and survey are on different levels.
• The software builds TIN surfaces from design file elements or from an ASCII file with a specific format.
• When building terrain models from design files elements are selected from levels. The user selects which level to add from a level map.
• The software imports lines into the surface as breaklines or just as points with the simple toggle of a button.
• The software reports results to output file and to a separate window.
• Has facility to clip TIN model.

Dislikes:
• In order to do a volume calculation, the user must create a clip polygon to bound the surfaces. In our cases this was a polygon which bounded the design channel. This is not hard to do, but it is an inconvenience.

• There are many different files that must be used in the process of importing data and computing volumes. The program has a facility to keep track of filenames, but the user still has to verify that the names are correct.
• When creating a surface model from ASCII data the user must convert their file to a neutral file format in order to read the data into GWN-DTM. This adds an extra step and another file name for the user to remember.
• There is no surface summary command. Points and triangle counts are reported as the model is entered and processed, but there is no review of the surface after the model is built.

RoadWorks(InXpress)/SiteWorks

RoadWorks is an older version of InXpress, Intergraph's roadway design product. The two products are virtually identical. SiteWorks is Intergraph's site design product. InXpress and SiteWorks function identically for TIN volume calculations. Each software package has different features, but their volume routines are very similar; therefore, they are reviewed together.

Vendor: Intergraph
Platforms: DOS, Unix(Clix), Sun
Other Software Required: MicroStation
As Tested: RoadWorks on PC(486-33MHz, 8MB RAM) with MicroStation PC Version 4.0 - SiteWorks on CLIX(IP 6450, 16 MB RAM) with MicroStation 32 Version 4.0

Likes-
• Speed. Both products build TIN's and calculate volumes very quickly.
• TIN's can be built from both ASCII and CADD file data.
• TIN's can be built from a CADD file using fence, level, and single element selection.
• The products have a nice surface manager capability. User need only remember a surface name to work with that surface.
• The user can set maximum triangle length and can use a clip polygon.
• The software imports lines and poly lines as breaklines or as random points.
• The software has a surface review, which gives information on points, triangles, and breaklines.
• The software has an excellent user interface. When building a TIN surface the user has a pull-down dialog box to select the appropriate surfaces. When doing the volume calculation, there are two pull-down menus from which the user selects the original and design surface.

Dislikes-
InXpress was unavailable for review, as it is a brand-new product. However, according to Intergraph, the new software functions very similarly to RoadWorks, the product which was tested. RoadWork, itself, is no longer available. InXpress is a

new product and, as is the case with any new product, there is the possibility of unresolved bugs in the program.

OTHER SOFTWARE

This is a list of other software products which may be used in volume calculations. These are not volume routines, but they may be used to improve the TIN creation/volume calculation process.

LACES TIN Master

LACES TIN Master is a stand-alone, PC-based system for editing digital terrain models and contouring. This program offers an easy and efficient method to modify TIN models through point-and-click procedures. For example, a displayed TIN model may not accurately represent a terrain feature, such as a point or ridge. With TIN Master, the user can alter the triangulation, add breaklines, or modify triangle vertices in the area of the feature. The remainder of the TIN is not altered, so time-consuming retriangulation and redrawing is avoided. The user can edit in plan, cross-section, or 3D views. The program offers the advantage of instant visual review of models, so blunders can be avoided. TIN Master works with TIN's generated in InRoads, RoadWorks, InXpress, Softdesk and Eagle Point. It reads .TIN, .DWG, and .DXF formats and writes .DGN, .DWG, and .DXF formats.

Vendor: Lamutt & Associates
Address: Suite 112
7114 West Jefferson Avenue
Lakewood, CO 80235
Phone: (303) 986-4909
FAX: (303) 986-2142
Platforms: DOS
Other Software Required: None

CVTPC2

CVTPC is a program to convert ASCII X-Y-Z survey data into Intergraph MicroStation Design Files. A file which contains up to six different fields, in any order, may be read into and converted by CVTPC.

Agency: U.S. Army Topographic Engineering Center
Address: ATTN: CETEC-TD-GS (Ruby)
7701 Telegraph Rd.
Alexandria, VA 22315-3864
Phone: (703) 355-2766
Platforms: DOS, Unix(Clix)
Other Software Required: MicroStation

Create Channel

Create Channel is a program that allows a user to build three-dimensional design surfaces of a channel for use with TIN's. The user inputs center line, toe line, and side slope information and the program will create a design channel which may then be used

to calculate volumes. Station-to-station channel sections may also be created.

Agency: U.S. Army Topographic Engineering Center
Address: ATTN: CETEC-TD-GS(Ruby)
7701 Telegraph Rd.
Alexandria, VA 22315-3864
Phone: (703) 355-2766
Platforms: DOS, Unix(Clix)
Other Software Required: MicroStation

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